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(54) **COMPATIBILIZER PRECURSOR,
METHODS, SYSTEMS, AND USES THEREOF,
AND FORMULATIONS INCLUDING THE
SAME**

(58) **Field of Classification Search**
CPC C08L 95/00; C08L 91/00; C08L 2205/035;
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See application file for complete search history.

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This patent is subject to a terminal dis-
claimer.

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Related U.S. Application Data

(63) Continuation of application No. 18/186,398, filed on
Mar. 20, 2023, now Pat. No. 12,187,896, which is a
continuation of application No. 17/112,489, filed on
Dec. 4, 2020, now Pat. No. 11,634,585.

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1, 2020, provisional application No. 62/944,727, filed
on Dec. 6, 2019.

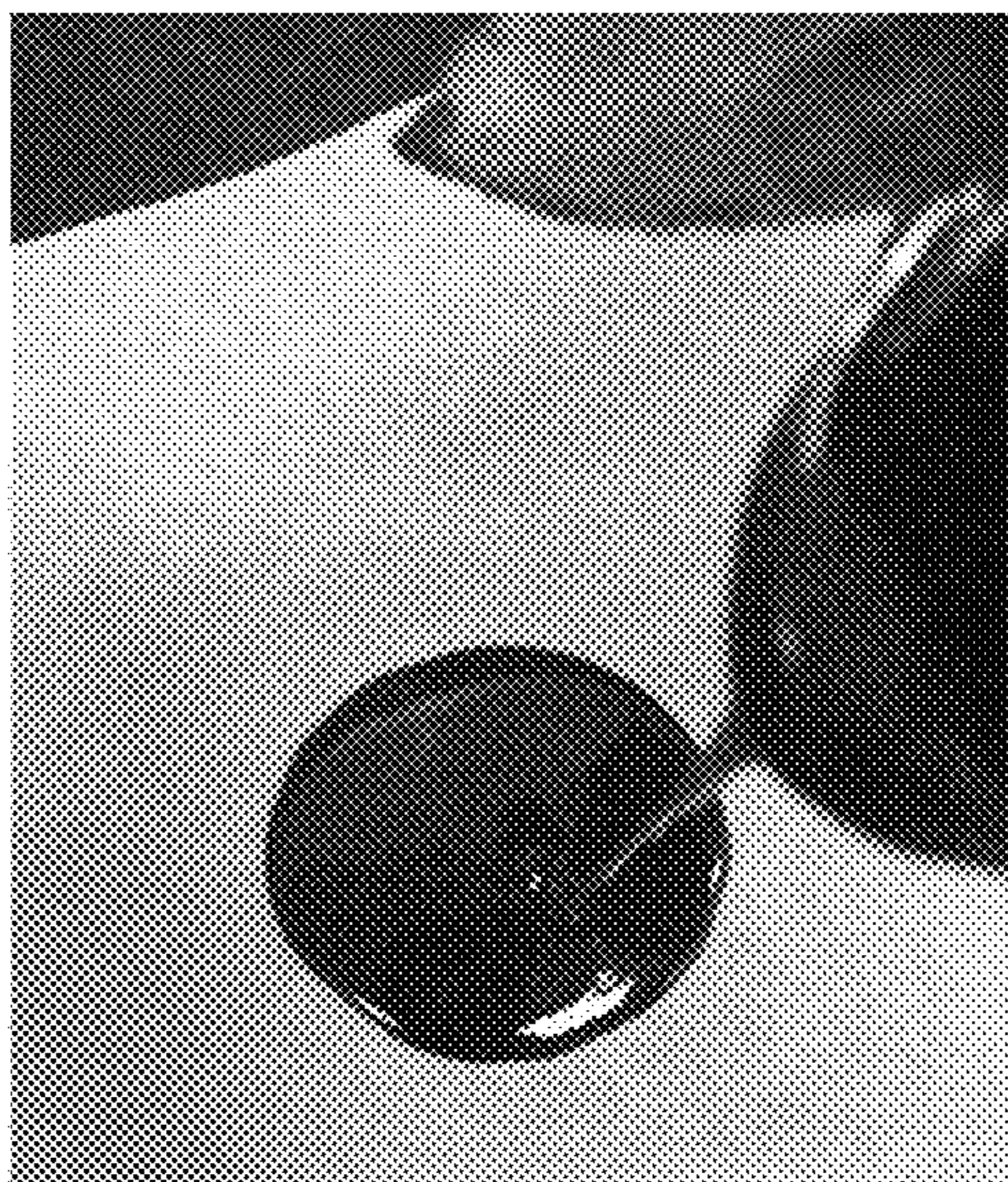
(57) **ABSTRACT**

Some embodiments of the present disclosure relate to a
method comprising mixing at least one compatibilizer pre-
cursor with at least one polymer, so as to result in a polymer
concentrate and mixing the polymer concentrate with
asphalt, so as to result in a polymer modified asphalt
("PMA"). Some embodiments of the present disclosure
relate to formulations comprising a compatibilizer precur-
sor, a polymer concentrate, PMA, or any combination
thereof.

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20 Claims, 4 Drawing Sheets



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FIG. 1



FIG. 2



FIG. 3

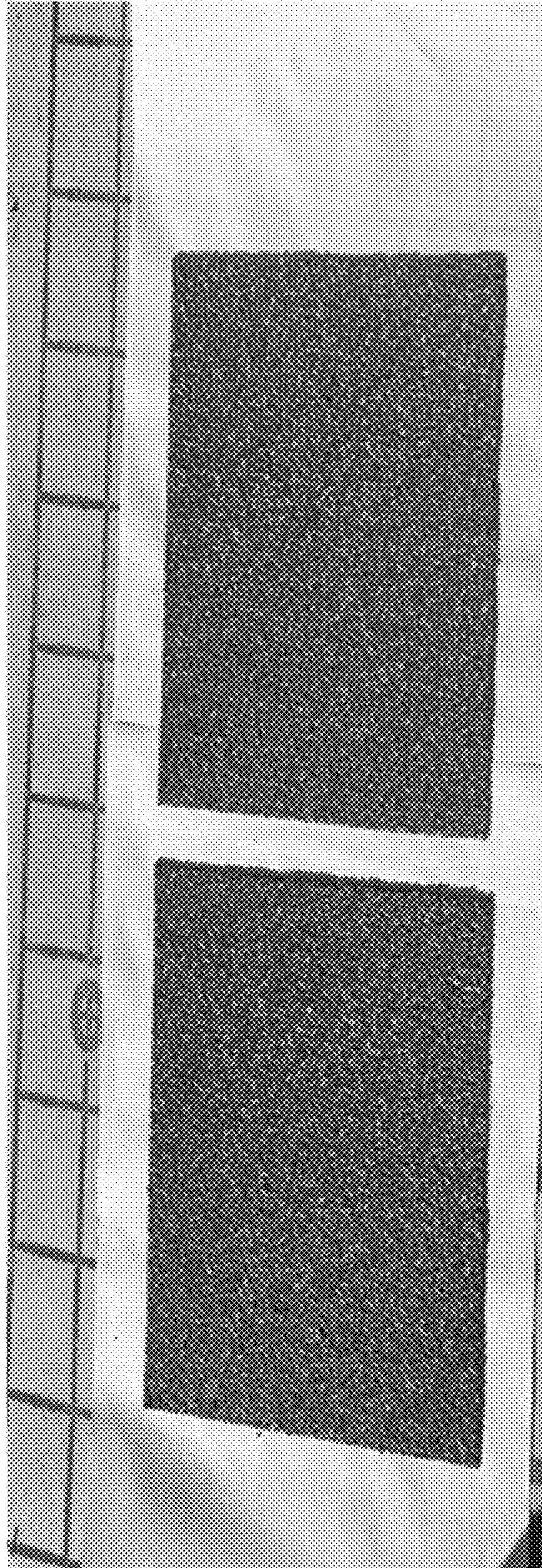


FIG. 4

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**COMPATIBILIZER PRECURSOR,
METHODS, SYSTEMS, AND USES THEREOF,
AND FORMULATIONS INCLUDING THE
SAME**

RELATED APPLICATIONS

The present application claims priority to U.S. Provisional Application No. 62/944,727, filed Dec. 6, 2019, and to U.S. Provisional Application No. 63/032,960, filed Jun. 1, 2020, each of which is incorporated herein in its respective entirety for all purposes.

FIELD

Some embodiments of the present disclosure relate to a polymer compatibilizer precursor that may be used for the modification of materials including, but not limited to, asphalt.

BACKGROUND

Mixing asphalt with polymers (including but not limited to, thermoplastic polymers) may pose challenges due to chemical incompatibilities. For instance, to produce polymer modified asphalt (PMA) with at least one uniformly dispersed polymer in an asphalt matrix, conventional methods may be inadequate. Improved methods, systems, formulations, and uses for improving the compatibility of polymers with asphalt are needed.

SUMMARY

Covered embodiments are defined by the claims, not this summary. This summary is a high-level overview of various aspects and introduces some of the concepts that are further described in the Detailed Description section below. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used in isolation to determine the scope of the claimed subject matter. The subject matter should be understood by reference to appropriate portions of the entire specification, any or all drawings, and each claim.

Some embodiments of the present disclosure relate to at least one compatibilizer precursor. In some embodiments, the at least one compatibilizer precursor is used for polymer modification of materials including, but not limited to, asphalt. In some embodiments, the at least one compatibilizer precursor is used to make roofing materials, including, but not limited to roofing shingles and flexible rolled roofing. In some embodiments, the roofing materials are manufactured using processes which are currently used in the roofing manufacturing industry.

Some embodiments of the present disclosure relate to method for making a concentrate by mixing the at least one compatibilizer precursor with asphalt. In some embodiments, the concentrate reduces the incompatibility gap between at least one polymer and asphalt, thereby facilitating preparation of polymer modified asphalt (PMA) using less mixing energy and shorter mixing time as compared to conventional methods (e.g., methods that apply high shearing energy for long shear mixing time, methods that use crosslinking agents, methods that use aging, methods that use curing, or any combination thereof). In some embodiments, at least one oil is added to the asphalt to influence the asphalt composition prior to or during mixing the asphalt and the at least one polymer.

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Some embodiments of the present disclosure relate to a method comprising mixing at least one compatibilizer precursor with at least one polymer, so as to result in a polymer concentrate. In some embodiments, the at least one polymer is mixed with the at least one compatibilizer precursor in a weight ratio of the at least one polymer to the at least one compatibilizer precursor of 1:100 to 2:1. In some embodiments the method further comprises mixing the polymer concentrate with asphalt, so as to result in a polymer modified asphalt (“PMA”).

In some embodiments, the at least one compatibilizer precursor comprises at least one resin, at least one process oil, or any combination thereof.

In some embodiments, the at least one resin comprises least one terpene resin, at least one petroleum resin, at least one hydrogenated rosin, at least one rosin milk, at least one petroleum resin emulsion, at least one terpene-phenolic resin, at least one hydrogenated petroleum resin, at least one aliphatic hydrocarbon resin, at least one hydrogenated aliphatic hydrocarbon resin, at least one aromatic modified aliphatic hydrocarbon resin, at least one hydrogenated aromatic modified aliphatic hydrocarbon resin, at least one polycyclopentadiene resin, at least one hydrogenated polycyclopentadiene resin, at least one cycloaliphatic hydrocarbon resin, at least one hydrogenated cycloaliphatic resin, cycloaliphatic/aromatic hydrocarbon resin, at least one hydrogenated cycloaliphatic/aromatic hydrocarbon resin, hydrogenated aromatic hydrocarbon resin, at least one maleic acid/anhydride modified tackifier, terpene modified aromatic and/or aliphatic hydrocarbon resin, at least one hydrogenated terpene modified aromatic and/or aliphatic hydrocarbon resin, at least one polyterpene resin, at least one hydrogenated polyterpene resin, at least one aromatic modified polyterpene resin, at least one hydrogenated aromatic modified polyterpene resin, at least one terpene-phenol resin, at least one hydrogenated terpene-phenol resin, at least one gum rosin resin, at least one hydrogenated gum rosin resin, at least one gum rosin ester resin, at least one wood rosin resin, at least one hydrogenated wood rosin resin, at least one rosin acid resin, at least one hydrogenated rosin acid resin, or any combination thereof.

In some embodiments, the at least one process oil comprises at least one paraffinic oil, at least one petroleum extract, at least one vegetable oil, at least one naphthenic oil, at least one aromatic oil, at least one re-refined engine oil bottom (REOB), at least one engine oil residue (EOR), at least one re-refined heavy vacuum distillation bottom (RHVDB), at least one re-refined heavy vacuum distillation oil (RHVDO), at least one re-refined vacuum tower bottom (RVTB), at least one vacuum tower bottom (VTB), or any combination thereof.

In some embodiments, the at least one polymer comprises at least one polyolefin, oxidized polyethylene (OPE), polyethylene-polypropylene elastomer, ground tire rubber (GTR), isotactic polypropylene (IPP), atactic polypropylene (APP), styrene-butadiene-styrene (SBS) copolymer, a styrene-ethylene-butylene-styrene (SEBS) copolymer, polyvinyl butyral (PVB) or any combination thereof.

In some embodiments, the polymer concentrate has a softening point of at least 195° F. as measured according to ASTM D36.

In some embodiments, the polymer concentrate has a softening point of 195° F. to 350° F. as measured according to ASTM D36.

In some embodiments, the polymer concentrate has a penetration point (“PEN”) of at least 15 dmm as measured according to ASTM D5.

In some embodiments, polymer concentrate has a penetration point of 15 dmm to 200 dmm as measured according to ASTM D5.

In some embodiments, wherein the polymer concentrate exhibits an elongation of 50% to 10,000% as tested according to ASTM D828.

In some embodiments, the asphalt has a softening point of at least 100° F. as measured according to ASTM D36.

In some embodiments, the asphalt has a softening point of 100° F. to 250° F. as measured according to ASTM D36.

In some embodiments, the asphalt has a penetration point of at least 2 dmm as measured according to ASTM D5.

In some embodiments, the asphalt has a penetration point of 1 dmm to 50 dmm as measured according to ASTM D5.

In some embodiments, the polymer modified asphalt has a softening point of at least 120 OF as measured according to ASTM D36.

In some embodiments, the polymer modified asphalt has a softening point of 120° F. to 300° F. as measured according to ASTM D36.

In some embodiments, the polymer modified asphalt has a penetration point of at least 10 dmm as measured according to ASTM D5.

In some embodiments, the polymer modified asphalt has a penetration point of 10 dmm to 50 dmm as measured according to ASTM D5.

In some embodiments, the method further comprises adding at least one filler, at least one additive, or any combination thereof to the polymer modified asphalt, so as to result in a filled polymer modified asphalt (“PMA”) coating.

In some embodiments, the at least one filler, the at least one additive, or combination thereof, comprises transoctenamer rubber (TOR) a propylene-based elastomer, at least one wax, calcium carbonate, barium sulfate, calcium sulfate, talc, limestone, perlite, silica, fumed silica, precipitated silica, quartz, aluminum trihydrate, magnesium hydroxide, colemanite, titanium dioxide, snow white, fly ash, graphene nanoparticles, carbon black, recycled rubber tires, recycled shingles, recycled thermoplastic resins, basalt, roofing granules, clay, ammonium polyphosphate, graphite, or any combination thereof.

In some embodiments, the filled PMA coating has a softening point of at least 200° F. as measured according to ASTM D36.

In some embodiments, the filled PMA coating has a softening point of 200° F. to 320° F. as measured according to ASTM D36.

In some embodiments, the filled PMA coating has a penetration point (“PEN”) of at least 5 dmm as measured according to ASTM D5.

In some embodiments, the filled PMA coating has a penetration point (“PEN”) of 5 dmm to 40 dmm as measured according to ASTM D5.

In some embodiments, mixing the at least one compatibilizer precursor with the at least one polymer is performed over a time period of 3 minutes to 90 minutes.

In some embodiments, mixing the polymer concentrate with asphalt is performed over a time period of 45 minutes to 90 minutes.

In some embodiments, the polymer concentrate is mixed with the asphalt in a weight ratio of the polymer concentrate to the asphalt of 1:50 to 1:1.

Some embodiments of the present disclosure relate to a formulation consisting essentially of: at least one polymer and at least one compatibilizer precursor. In some embodiments, the at least one polymer is present in the formulation

in a weight ratio of the at least one polymer to the at least one compatibilizer precursor of 1:100 to 2. In some embodiments, the formulation is a polymer concentrate

Some embodiments of the present disclosure relate to a formulation consisting essentially of: at least one polymer, at least one compatibilizer precursor, asphalt, optionally, at least one filler, and optionally, at least one additive. In some embodiments, the at least one polymer is present in the formulation in a weight ratio of the at least one polymer to the asphalt of 1:100 to 1:2. In some embodiments, the at least one compatibilizer precursor is present in the formulation in a weight ratio of the at least one compatibilizer precursor to the asphalt of 1:50 to 1:1. In some embodiments, the formulation is a polymer modified asphalt (PMA).

Some embodiments of the present disclosure relate to a formulation comprising: at least one polymer, at least one compatibilizer precursor, and asphalt. In some embodiments, the at least one polymer is present in the formulation in a weight ratio of the at least one polymer to the asphalt of 1:100 to 1:2. In some embodiments, the at least one compatibilizer precursor is present in the formulation in a weight ratio of the at least one compatibilizer precursor to the asphalt of 1:50 to 1:1. the formulation is a polymer modified asphalt (PMA).

BRIEF DESCRIPTION OF DRAWINGS

Some embodiments of the disclosure are herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the embodiments shown are by way of example and for purposes of illustrative discussion of embodiments of the disclosure. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the disclosure may be practiced.

FIG. 1 depicts a non-limiting exemplary prototype of a compatibilizer precursor according to the present disclosure.

FIGS. 2 and 3 depict non-limiting exemplary prototypes of a mat coated with a finished filled coating described herein.

FIG. 4 depicts a non-limiting exemplary prototype of a shingle prepared with the finished filled coating described herein.

DETAILED DESCRIPTION

Among those benefits and improvements that have been disclosed, other objects and advantages of this disclosure will become apparent from the following description taken in conjunction with the accompanying figures. Detailed embodiments of the present disclosure are disclosed herein; however, it is to be understood that the disclosed embodiments are merely illustrative of the disclosure that may be embodied in various forms. In addition, each of the examples given regarding the various embodiments of the disclosure which are intended to be illustrative, and not restrictive.

Throughout the specification and claims, the following terms take the meanings explicitly associated herein, unless the context clearly dictates otherwise. The phrases “in one embodiment,” “in an embodiment,” and “in some embodiments” as used herein do not necessarily refer to the same embodiment(s), though it may. Furthermore, the phrases “in another embodiment” and “in some other embodiments” as used herein do not necessarily refer to a different embodi-

ment, although it may. All embodiments of the disclosure are intended to be combinable without departing from the scope or spirit of the disclosure.

As used herein, the term “based on” is not exclusive and allows for being based on additional factors not described, unless the context clearly dictates otherwise. In addition, throughout the specification, the meaning of “a,” “an,” and “the” include plural references. The meaning of “in” includes “in” and “on.”

All prior patents, publications, and test methods referenced herein are incorporated by reference in their entireties.

Variations, modifications and alterations to embodiments of the present disclosure described above will make themselves apparent to those skilled in the art. All such variations, modifications, alterations and the like are intended to fall within the spirit and scope of the present disclosure, limited solely by the appended claims.

Some embodiments of the present disclosure relate to a compatibilizer precursor. As defined herein, a compatibilizer precursor is any component or combination of components that, when combined with at least one polymer, improves miscibility of the at least one polymer in asphalt, relative to a miscibility of the polymer in asphalt without the at least one compatibilizer precursor present.

In some embodiments, the at least one compatibilizer precursor comprises at least one resin, at least one process oil, or any combination thereof.

In some embodiments, the at least one resin comprises least one terpene resin, at least one petroleum resin, at least one hydrogenated rosin, at least one rosin milk, at least one petroleum resin emulsion, at least one terpene-phenolic resin, at least one hydrogenated petroleum resin, at least one aliphatic hydrocarbon resin, at least one hydrogenated aliphatic hydrocarbon resin, at least one aromatic modified aliphatic hydrocarbon resin, at least one hydrogenated aromatic modified aliphatic hydrocarbon resin, at least one polycyclopentadiene resin, at least one hydrogenated polycyclopentadiene resin, at least one cycloaliphatic hydrocarbon resin, at least one hydrogenated cycloaliphatic resin, cycloaliphatic/aromatic hydrocarbon resin, at least one hydrogenated cycloaliphatic/aromatic hydrocarbon resin, hydrogenated aromatic hydrocarbon resin, at least one maleic acid/anhydride modified tackifier, terpene modified aromatic and/or aliphatic hydrocarbon resin, at least one hydrogenated terpene modified aromatic and/or aliphatic hydrocarbon resin, at least one polyterpene resin, at least one hydrogenated polyterpene resin, at least one aromatic modified polyterpene resin, at least one hydrogenated aromatic modified polyterpene resin, at least one terpene-phenol resin, at least one hydrogenated terpene-phenol resin, at least one gum rosin resin, at least one hydrogenated gum rosin resin, at least one gum rosin ester resin, at least one wood rosin resin, at least one hydrogenated wood rosin resin, at least one rosin acid resin, at least one hydrogenated rosin acid resin, or any combination thereof.

In some embodiments, the at least one process oil comprises at least one paraffinic oil, at least one petroleum extract, at least one vegetable oil, at least one naphthenic oil, at least one aromatic oil, at least one re-refined engine oil bottom (REOB), at least one engine oil residue (EOR), at least one re-refined heavy vacuum distillation bottom (RHVDB), at least one re-refined heavy vacuum distillation oil (RHVDO), at least one re-refined vacuum tower bottom (RVTB), at least one vacuum tower bottom (VTB), or any combination thereof.

In some embodiments, the at least one compatibilizer precursor reduces an incompatibility gap between at least

one polymer and asphalt. In some embodiments, the reduction in the incompatibility gap provides improved dispersion of the at least one polymer in an asphalt matrix. In some embodiments, the improved dispersion results in a more stable coating mixed for shorter time as compared to conventional methods.

In some embodiments, the at least one compatibilizer precursor is used for polymer modification of asphalt. In some embodiments, the at least one compatibilizer precursor is used for polymer modification of at least one non-asphaltic coating. In some embodiments, the at least one compatibilizer precursor is used for polymer modification of combinations of asphalt and at least one non-asphaltic coating.

In some embodiments, the at least one compatibilizer precursor is prepared by mixing at least one polymer (including, but not limited to, a thermoplastic polymer) with the at least one compatibilizer precursor, which may comprise at least one oil (including but not limited to a conveyor oil, such as a hydrocarbon oil, a process oil, or any combination thereof), so as to form a polymer concentrate.

As defined herein, a “polymer concentrate” is a mixture of at least one compatibilizer precursor and at least one polymer. In some embodiments, the concentrate is a “polymer rich” concentrate. In some embodiments, the mixing is performed with a “high shear” mixer. In some embodiments, the mixing is performed with a “low shear” mixer. Non-limiting examples of “high shear mixers” are described herein in the examples.

In some embodiments, the at least one polymer comprises at least one polyolefin, oxidized polyethylene (OPE), polyethylene-polypropylene elastomer, ground tire rubber (GTR), isotactic polypropylene (IPP), atactic polypropylene (APP), styrene-butadiene-styrene (SBS) copolymer, a styrene-ethylene-butylene-styrene (SEBS) copolymer, polyvinyl butyral (PVB) or any combination thereof.

In some embodiments, the at least one polymer comprises styrenic block copolymer and the at least one oil comprises Hydrolene®. In some embodiments, a concentrate comprising styrenic block copolymer and Hydrolene® comprises up to 50% of styrenic block copolymer by total weight of the concentrate. In some embodiments, a concentrate comprising styrenic block copolymer and Hydrolene® comprises up to 40% of styrenic block copolymer by total weight of the concentrate. In some embodiments, a concentrate comprising styrenic block copolymer and Hydrolene® comprises up to 30% of styrenic block copolymer by total weight of the concentrate. In some embodiments, a concentrate comprising styrenic block copolymer and Hydrolene® comprises up to 20% of styrenic block copolymer by total weight of the concentrate. In some embodiments, a concentrate comprising styrenic block copolymer and Hydrolene® comprises up to 10% of styrenic block copolymer by total weight of the concentrate.

In some embodiments, the at least one polymer may comprise at least one polymer chosen from: a polyolefin, an ethylene based polymer, an amorphous polyalphaolefin, polypropylene/polyvinyl butyral, or any combination thereof.

Specific, commercially available, non-limiting examples of the at least one polymer according to the present disclosure include: Kraton™ SBS, Kraton™ SEBS, Rextac® 2304, or any combination thereof.

In some embodiments, the at least one compatibilizer precursor works by filling an incompatibility gap between the at least one polymer and the asphalt, so as to provide improved dispersion of the at least one polymer in an asphalt

matrix. In some embodiments, the filling of the incompatibility gap is achieved by influencing at least one of: shape, size or spatial distribution of a plurality of phases of the at least one polymer, the asphalt, or any combination thereof. In some embodiments, the filling of the incompatibility gap may stem from the at least one compatibilizer precursor influencing an intricate interplay between viscoelasticity of each phase of the plurality of phases of the at least one polymer, the asphalt, or any combination thereof. In some embodiments, the filling of the incompatibility gap may stem from the at least one compatibilizer precursor modifying properties of at least one interface between the at least one polymer and asphalt. In some embodiments, the filling of the incompatibility gap may stem from a blend composition of the at least one polymer, the asphalt, or any combination thereof.

In some embodiments, modifying the asphalt with the at least one compatibilizer precursor may improve miscibility between an asphalt micellular structure and the at least one polymer. In some embodiments, modifying the asphalt with the at least one compatibilizer precursor may improve an interfacial area between an asphalt micellular structure and the at least one polymer. In some embodiments, modifying the asphalt with the at least one compatibilizer precursor may improve adhesion between the at least one polymer and a plurality of asphalt micelles. In some embodiments, modifying the asphalt with the at least one compatibilizer precursor may improve phase morphology.

In some embodiments, the improvements are relative to methods and systems where the asphalt, the at least one oil, and the at least one polymer had been batched together prior to mixing. In some embodiments, when the at least one oil is added to the asphalt, compatibility between the polymer and the asphalt is improved when compared to a system consisting of (i.e., including only) asphalt and at least one polymer described herein.

In some embodiments, compatibilizer molecules are formed. In some embodiments, the compatibilizer molecules are formed at surfaces of small generated particles. In some embodiments, the formation of the compatibilizer molecules diminishes coalescence of polymer modified asphalt (PMA) during subsequent processing.

In some embodiments, any aspect of the disclosure herein may reduce mixing time, reduce dynamic coalescence, reduce static coalescence, or any combination thereof. In some embodiments, any aspect of the disclosure herein may result in a more stable PMA coating, a more stable polymer-modified-non-asphaltic coating or any combination thereof. In some embodiments, any aspect of the disclosure herein may provide for an ability to incorporate higher polymer loadings into PMA to achieve enhanced performance.

In some embodiments, formulations may be prepared by adding the at least one compatibilizer precursor to asphalt, such that a resulting PMA can be tested. In some embodiments, the formulations may be prepared into coatings. In some embodiments, the coatings may comprise at least one filler including, but not limited to: at least one mineral filler, limestone, fiberglass particles, stone dust, or any combination thereof. In some embodiments, the coatings may be tested for use in shingle and roofing fabrication.

In some embodiments, the coatings may comprise at least one additive. In some embodiments, the at least one additive comprises at least one wax including, but not limited to, at least one liquid wax, at least one solid wax, or any combination thereof. In some embodiments, the at least one wax may comprise a polyacrylic acid wax, a polyamide wax, or a combination thereof (herein referred to individually or

collectively as "PAA" wax). In some embodiments, the at least one additive comprises transoctenamer rubber (TOR). In some embodiments, the at least one additive comprises at least one propylene-based elastomer, a non-limiting example of which is Vistamaxx™ 6102 from Exxon-Mobil®.

In some embodiments, laboratory coupons may be prepared by applying the coatings to a substrate. In some embodiments the substrate may be a mat. In some embodiments, the mat is a glass mat or fiberglass mat. In some embodiments, a surface protective material such as granules may be applied to the substrate. In some embodiments, the laboratory coupons may be tested for properties applicable to shingles, such as roofing shingles.

Some embodiments of the present disclosure relate to a method of using the at least one compatibilizer precursor to manufacture at least one of the following: a polymer concentrate, a polymer modified asphalt, a filled asphalt coating, at least one roofing product (such as, but not limited to a roofing shingle), or any combination thereof.

In some embodiments, an exemplary method comprises mixing at least one compatibilizer precursor with at least one polymer, so as to result in the polymer concentrate.

In some embodiments, the mixing of the at least one compatibilizer precursor with the at least one polymer is performed over a time period of 3 minutes to 90 minutes. In some embodiments, the mixing of the at least one compatibilizer precursor with the at least one polymer is performed over a time period of 10 minutes to 90 minutes. In some embodiments, the mixing of the at least one compatibilizer precursor with the at least one polymer is performed over a time period of 30 minutes to 90 minutes. In some embodiments, the mixing of the at least one compatibilizer precursor with the at least one polymer is performed over a time period of 45 minutes to 90 minutes. In some embodiments, the mixing of the at least one compatibilizer precursor with the at least one polymer is performed over a time period of 60 minutes to 90 minutes.

In some embodiments, the mixing of the at least one compatibilizer precursor with the at least one polymer is performed over a time period of 3 minutes to 60 minutes. In some embodiments, the mixing of the at least one compatibilizer precursor with the at least one polymer is performed over a time period of 3 minutes to 45 minutes. In some embodiments, the mixing of the at least one compatibilizer precursor with the at least one polymer is performed over a time period of 3 minutes to 30 minutes. In some embodiments, the mixing of the at least one compatibilizer precursor with the at least one polymer is performed over a time period of 3 minutes to 10 minutes.

In some embodiments, the mixing of the at least one compatibilizer precursor with the at least one polymer is performed over a time period of 10 minutes to 60 minutes. In some embodiments, the mixing of the at least one compatibilizer precursor with the at least one polymer is performed over a time period of 30 minutes to 45 minutes.

In some embodiments, mixing the compatibilizer precursor with asphalt is performed over a time period that is less than a comparative time period where the at least one polymer is mixed with asphalt, using at least one mixer of the same type, but where the compatibilizer precursor is not present in the at least one mixer during the comparative time period.

In some embodiments, mixing the compatibilizer precursor with asphalt is performed over a time period that is 1% to 99% less than a comparative time period where the at least one polymer is mixed with asphalt, using at least one mixer

In some embodiments, the polymer modified asphalt (“PMA”) that results from the mixing of the asphalt and the polymer concentrate has a softening point of at least 120° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of at least 125° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of at least 150° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of at least 175 OF as measured according to ASTM D36. In some embodiments, the PMA that results from the mixing of the asphalt and the polymer concentrate has a softening point of at least 200° F. as measured according to ASTM D36. In some embodiments, the PMA that results from the mixing of the asphalt and the polymer concentrate has a softening point of at least 225° F. as measured according to ASTM D36. In some embodiments, the PMA that results from the mixing of the asphalt and the polymer concentrate has a softening point of at least 250° F. as measured according to ASTM D36. In some embodiments, the PMA that results from the mixing of the asphalt and the polymer concentrate has a softening point of at least 275° F. as measured according to ASTM D36. In some embodiments, PMA that results from the mixing of the asphalt and the polymer concentrate has a softening point of at least 300° F. as measured according to ASTM D36.

In some embodiments, the PMA has a softening point of 120° F. to 300° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 150° F. to 300° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 150° F. to 300° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 175° F. to 300° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 200° F. to 300° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 225° F. to 300° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 250° F. to 300° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 275° F. to 300° F. as measured according to ASTM D36.

In some embodiments, the PMA has a softening point of 120° F. to 275° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 120° F. to 250° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 120° F. to 225° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 120° F. to 200° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 120° F. to 175° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 120° F. to 150° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 120° F. to 125° F. as measured according to ASTM D36.

In some embodiments, the PMA has a softening point of 125° F. to 275° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 125° F. to 250° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 125° F. to 200° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 125° F. to 175° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 125° F. to 150° F. as measured according to ASTM D36.

In some embodiments, the PMA has a softening point of 125° F. to 275° F. as measured according to ASTM D36. In

some embodiments, the PMA has a softening point of 150° F. to 250° F. as measured according to ASTM D36. In some embodiments, the PMA has a softening point of 175° F. to 225° F. as measured according to ASTM D36.

In some embodiments, the PMA has a penetration point (“PEN”) of at least 10 dmm as measured according to ASTM D5. In some embodiments, the PMA has a PEN of at least 20 dmm as measured according to ASTM D5. In some embodiments, the PMA has a PEN of at least 30 dmm as measured according to ASTM D5. In some embodiments, the PMA has a PEN of at least 40 dmm as measured according to ASTM D5. In some embodiments, the PMA has a PEN of at least 50 dmm as measured according to ASTM D5.

In some embodiments, the PMA has a PEN of 10 dmm to 50 dmm as measured according to ASTM D5. In some embodiments, the PMA has a PEN of 20 dmm to 50 dmm as measured according to ASTM D5. In some embodiments, the PMA has a PEN of 30 dmm to 50 dmm as measured according to ASTM D5. In some embodiments, the PMA has a PEN of 40 dmm to 50 dmm as measured according to ASTM D5.

In some embodiments, the PMA has a PEN of 10 dmm to 40 dmm as measured according to ASTM D5. In some embodiments, the PMA has a PEN of 20 dmm to 30 dmm as measured according to ASTM D5.

In some embodiments, the method further comprises adding at least one filler, at least one additive, or any combination thereof to the polymer modified asphalt (“PMA”), so as to result in a filled PMA coating.

In some embodiments, the at least one filler, the at least one additive, or combination thereof, comprises transoctamer rubber (TOR) a propylene-based elastomer, at least one wax, calcium carbonate, barium sulfate, calcium sulfate, talc, limestone, perlite, silica, fumed silica, precipitated silica, quartz, aluminum trihydrate, magnesium hydroxide, colemanite, titanium dioxide, snow white, fly ash, graphene nanoparticles, carbon black, recycled rubber tires, recycled shingles, recycled thermoplastic resins, basalt, roofing granules, clay, ammonium polyphosphate, graphite, or any combination thereof.

In some embodiments, the filled PMA coating has a softening point of at least 200° F. as measured according to ASTM D36. In some embodiments, the filled PMA coating has a softening point of at least 225° F. as measured according to ASTM D36. In some embodiments, the filled PMA coating has a softening point of at least 250° F. as measured according to ASTM D36. In some embodiments, the filled PMA coating has a softening point of at least 275° F. as measured according to ASTM D36. In some embodiments, the filled PMA coating has a softening point of at least 300° F. as measured according to ASTM D36. In some embodiments, the filled PMA coating has a softening point of at least 325° F. as measured according to ASTM D36.

In some embodiments, the filled PMA coating has a softening point of 200° F. to 320° F. as measured according to ASTM D36. In some embodiments, the filled PMA coating has a softening point of 220° F. to 300° F. as measured according to ASTM D36. In some embodiments, the filled PMA coating has a softening point of 240° F. to 300° F. as measured according to ASTM D36. In some embodiments, the filled PMA coating has a softening point of 260° F. to 300° F. as measured according to ASTM D36. In some embodiments, the filled PMA coating has a softening point of 280° F. to 300° F. as measured according to ASTM D36.

ASTM D828. In some embodiments, the polymer concentrate exhibits an elongation of 500% to 1000% as tested according to ASTM D828.

Some embodiments of the present disclosure relate to the polymer modified asphalt (PMA) described herein. In some embodiments, the PMA is a formulation that comprises at least one polymer, at least one compatibilizer precursor, and asphalt. In some embodiments, the PMA is a formulation that consists of least one polymer, at least one compatibilizer precursor, and asphalt. In some embodiments, the PMA is a formulation that consists essentially of least one polymer, at least one compatibilizer precursor, and asphalt. In some embodiments, the PMA also includes at least one filler described herein, at least one additive described herein, or any combination thereof.

In some embodiments, the at least one polymer is present in the PMA formulation in a weight ratio of the at least one polymer to the asphalt of 1:100 to 1:2. In some embodiments, the at least one polymer is present in the PMA formulation in a weight ratio of the at least one polymer to the asphalt of 1:50 to 1:2. In some embodiments, the at least one polymer is present in the PMA formulation in a weight ratio of the at least one polymer to the asphalt of 1:20 to 1:2. In some embodiments, the at least one polymer is present in the PMA formulation in a weight ratio of the at least one polymer to the asphalt of 1:10 to 1:2. In some embodiments, the at least one polymer is present in the PMA formulation in a weight ratio of the at least one polymer to the asphalt of 1:5 to 1:2.

In some embodiments, the at least one polymer is present in the PMA formulation in a weight ratio of the at least one polymer to the asphalt of 1:100 to 1:5. In some embodiments, the at least one polymer is present in the PMA formulation in a weight ratio of the at least one polymer to the asphalt of 1:100 to 1:10. In some embodiments, the at least one polymer is present in the PMA formulation in a weight ratio of the at least one polymer to the asphalt of 1:100 to 1:20. In some embodiments, the at least one polymer is present in the PMA formulation in a weight ratio of the at least one polymer to the asphalt of 1:100 to 1:50.

In some embodiments, the at least one polymer is present in the PMA formulation in a weight ratio of the at least one polymer to the asphalt of 1:50 to 1:2. In some embodiments, the at least one polymer is present in the PMA formulation in a weight ratio of the at least one polymer to the asphalt of 1:20 to 1:5.

In some embodiments, the at least one compatibilizer precursor is present in the PMA formulation in a weight ratio of the at least one compatibilizer precursor to the asphalt of 1:50 to 1:1. In some embodiments, the at least one compatibilizer precursor is present in the PMA formulation in a weight ratio of the at least one compatibilizer precursor to the asphalt of 1:20 to 1:1. In some embodiments, the at least one compatibilizer precursor is present in the PMA formulation in a weight ratio of the at least one compatibilizer precursor to the asphalt of 1:10 to 1:1. In some embodiments, the at least one compatibilizer precursor is present in the PMA formulation in a weight ratio of the at least one compatibilizer precursor to the asphalt of 1:5 to 1:1. In some embodiments, the at least one compatibilizer precursor is present in the PMA formulation in a weight ratio of the at least one compatibilizer precursor to the asphalt of 1:2 to 1:1.

In some embodiments, the at least one compatibilizer precursor is present in the PMA formulation in a weight ratio of the at least one compatibilizer precursor to the asphalt of 1:50 to 1:2. In some embodiments, the at least one com-

patibilizer precursor is present in the PMA formulation in a weight ratio of the at least one compatibilizer precursor to the asphalt of 1:50 to 1:10. In some embodiments, the at least one compatibilizer precursor is present in the PMA formulation in a weight ratio of the at least one compatibilizer precursor to the asphalt of 1:50 to 1:20.

In some embodiments, the at least one compatibilizer precursor is present in the PMA formulation in a weight ratio of the at least one compatibilizer precursor to the asphalt of 1:20 to 1:2. In some embodiments, the at least one compatibilizer precursor is present in the PMA formulation in a weight ratio of the at least one compatibilizer precursor to the asphalt of 1:10 to 1:5.

A non-limiting exemplary prototype of a compatibilizer precursor according to the present disclosure is shown in FIG. 1. As shown by FIG. 1, in some embodiments, the at least one compatibilizer precursor may take the form of a concentrate. In some embodiments, the concentrate may be a polymer concentrate comprising the at least one compatibilizer precursor and the at least one polymer described herein.

Non-limiting exemplary prototypes of a mat coated with a finished filled coating are shown in FIGS. 2 and 3. In some embodiments, the finished filled coating of FIG. 2 or 3 is prepared using the at least one compatibilizer precursor described herein. In some embodiments, the finished filled coating includes at least one filler described herein. In some embodiments, the finished filled coating is prepared by combining the at least one compatibilizer precursor described herein with asphalt. In some embodiments, the finished filled coating is prepared by combining the at least one compatibilizer precursor described herein with a non-asphaltic component. In some embodiments, the finished filled coating is prepared by combining the at least one compatibilizer precursor described herein with both an asphaltic and a non-asphaltic component.

FIG. 4 depicts a non-limiting exemplary prototype of a shingle prepared with the finished filled coating described herein. In some embodiments, the shingle may be a roofing shingle.

EXAMPLES

Non-Limiting Example 1

Example filled coatings were prepared using the at least one compatibilizer precursor described herein. In the present non-limiting example, the at least one compatibilizer precursor took the form of concentrates A-E. In the present non-limiting example, each of concentrates A-E included specified amounts of a compatibilizer precursor in the form of an oil (i.e., Hydrolene® or Process Oil) and at least one polymer (i.e., Kraton™ SBS, Kraton™ SEBS, or a combination of recycled polyvinyl butyral “PVB” and Rextac® 2304 polyalphaolefin). Each of concentrates A-D were combined with asphalt (Asphalt K-M) to form Polymer Modified Asphalt (“PMA”) formulations I-IV. PMA formulation V was also formed, as indicated in Table 1 below. PMA formulations I-V were combined with specified amounts of filler to form filled coatings (Filled coatings 1-5).

In one embodiment of the present example, a PAA wax additive described herein was added. In another embodiment of the present example, additives in the form of transoctenamer rubber (TOR) and a propylene-based elastomer (Vistamaxx™) were added.

Several properties (i.e., softening point, viscosity, and penetration point “PEN”) were tested. Polymer concentrates

A, B, D, and, E were formed, mixed with the base asphalt, and mixed with the filler using a “high shear mixer” manufactured by Silverson®. Polymer concentrate C was formed, mixed with the base asphalt, and mixed with the filler using a continuous “high shear mixer” manufactured by Readco. 5
All mixing times ranged from 3 minutes to 90 minutes. Results of the tests shown in Table 1 below.

TABLE 1

Non-limiting properties of certain concentrates, asphalts, polymer modified asphalt formulations, and filled coatings:			
Material	Softening	Viscosity at 400° F. (cP)	PEN
	Point (° F.) ASTM D36		(dmm) at 77° F. ASTM D5
Polymer Concentrate A (80% Hydrolene H600T/20% Kraton SBS D1191ET)	242	2474	120
Base Asphalt K	210	296	15
Polymer Modified Asphalt (“PMA”) 1-90.0% Base Asphalt K/10.0% Concentrate A = Formulation I	211	349	18
PMA Filled coating 1(35% Formulation I/65% filler)	243	3108	8
Polymer Concentrate B (74.5% Hydrolene H600T/24.5% Kraton SBS D1191ET)	263	6208	107
Base Asphalt L	177	123	2.3
PMA 2-73.5% Base Asphalt L/26.5% Concentrate B = Formulation II	225	302	18
PMA Filled coating 2 (Formulation II + 67% filler)	245	2212	9.3
Polymer Concentrate C (70% Hydrolene H600T/30% Kraton SBS D1191ET)	>320	Not measured	101
Asphalt M	160	67	5
PMA 3-78.5% Asphalt M/21.5% Concentrate C = Formulation III	218	251	20
Filled coating 3 (Formulation III + 66% filler)	251	1978	9
Polymer Concentrate D (50% Hydrolene H90T/50% Kraton SEBS G1642)	280.2	58388	33.3
Asphalt N	169	153	15
PMA 4-91.0% Asphalt N/8.0% Concentrate D/1.0% PAA wax = Formulation IV	206	305	17.3
PMA Filled coating 4 (Formulation IV + 65% filler)	235.1	3984	7.7
Polymer Concentrate E (30.6% H600T/33.8% Rextac ® 2304/8.8% Vistamaxx™ 6102/4.4% TOR 8012/22.4% recycled PVB	Not measured	Not measured	Not measured
Process Oil H600T O	Liquid at room temperature		
PMA 5--13.6% Process Oil H600T O/86.4% Concentrate E = Formulation V	275	1357	60
PMA Filled coating 5 (Formulation V + 63% filler)	282	10750	32

Comparative Example 1

Asphalt P was combined with the same polymer (Kraton SBS D1191ET) of polymer concentrates A, B, and C, so as to form a comparative polymer modified asphalt (PMA) formulation. The same high shear mixer (manufactured by Silverson®) used to form polymer concentrates A, B, D, and, E was used to form the comparative PMA formulation. However, in the present comparative example, no compatibilizer precursor was used.

Mixing time for mixing the asphalt with the polymer without the compatibilizer precursor, exceeded 150 minutes.

Several properties (i.e., softening point, viscosity, and penetration point “PEN”) of both the base asphalt and the comparative PMA formulation were tested. Results are shown below in Table 2.

TABLE 2

Non-limiting properties of asphalt and a comparative polymer modified asphalt (PMA) formulation			
Material	Softening	Viscosity at 400° F. (cP)	PEN
	Point (° F.) ASTM D36		(dmm) at 77° F. ASTM D5
Base Asphalt P	209.6	250	14
Comparative PMA--97% Asphalt P/3% Kraton SBS D1191ET	212	340	11

While several embodiments of the present disclosure have been described, it is understood that these embodiments are illustrative only, and not restrictive, and that many modifications may become apparent to those of ordinary skill in the

art. For example, all dimensions discussed herein are provided as examples only, and are intended to be illustrative and not restrictive.

Any feature or element that is positively identified in this description may also be specifically excluded as a feature or element of an embodiment of the present as defined in the claims.

As used herein, the term “consisting essentially of” limits the scope of a specific claim to the specified materials or steps and those that do not materially affect the basic and novel characteristic or characteristics of the specific claim. In some embodiments, a claim reciting “consisting essentially of” may allow for the addition of any unrecited component that does not materially affect at least one of the following: softening point of at least one component or combination of components, penetration point of at least one component or combination of components, elongation of at least one component or combination of components, or any combination thereof. In some embodiments, a claim reciting “consisting essentially of” may allow for the addition of at least one additive, at least one filler, or any combination thereof.

The disclosure described herein may be practiced in the absence of any element or elements, limitation or limitations, which is not specifically disclosed herein. Thus, for example, in each instance herein, any of the terms “comprising,” “consisting essentially of” and “consisting of” may be replaced with either of the other two terms. The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the disclosure.

The invention claimed is:

1. A method comprising:

mixing at least one compatibilizer precursor with at least one polymer, so as to result in a polymer concentrate, wherein the at least one compatibilizer precursor comprises at least one paraffinic oil, at least one petroleum extract, at least one naphthenic oil, at least one aromatic oil, at least one re-refined engine oil bottom (REOB), at least one engine oil residue (EOR), at least one re-refined heavy vacuum distillation bottom (RHVDB), at least one re-refined heavy vacuum distillation oil (RHVDO), at least one re-refined vacuum tower bottom (RVTB), at least one vacuum tower bottom (VTB), or any combination thereof; and

mixing the polymer concentrate with asphalt in a mixer to form a polymer modified asphalt (“PMA”).

2. The method of claim 1, wherein the at least one polymer is mixed with the at least one compatibilizer precursor in a weight ratio of the at least one polymer to the at least one compatibilizer precursor of 1:100 to 2:1.

3. The method of claim 1, wherein the at least one polymer is mixed with the at least one compatibilizer precursor in a weight ratio of the at least one polymer to the at least one compatibilizer precursor of 1:10 to 2:1.

4. The method of claim 1, wherein the at least one polymer is mixed with the at least one compatibilizer precursor in a weight ratio of the at least one polymer to the at least one compatibilizer precursor of 1:5 to 2:1.

5. The method of claim 1, wherein the at least one compatibilizer precursor comprises at least one resin, at least one process oil, or any combination thereof.

6. The method of claim 1, wherein the at least one at least one compatibilizer precursor comprises at least one aromatic oil.

7. The method of claim 6, wherein the at least one aromatic oil comprises HYDROLENE®.

8. The method of claim 1, wherein the at least one polymer comprises at least one polyolefin, oxidized polyethylene (OPE), polyethylene-polypropylene elastomer, ground tire rubber (GTR), isotactic polypropylene (IPP), atactic polypropylene (APP), styrene-butadiene-styrene (SBS) copolymer, a styrene-ethylene-butylene-styrene (SEBS) copolymer, polyvinyl butyral (PVB) or any combination thereof.

9. The method of claim 1, wherein the at least one polymer comprises oxidized polyethylene (OPE).

10. The method of claim 1, wherein the at least one polymer comprises a styrene-ethylene-butylene-styrene (SEBS) copolymer.

11. The method of claim 1, wherein the polymer concentrate has a softening point of 195° F. to 350° F. as measured according to ASTM D36.

12. The method of claim 1, wherein the polymer concentrate has a penetration point of 15 dmm to 200 dmm as measured according to ASTM D5.

13. The method of claim 1, wherein the asphalt has a softening point of 100° F. to 250° F. as measured according to ASTM D36.

14. The method of claim 1, wherein the asphalt has a penetration point of 1 dmm to 50 dmm as measured according to ASTM D5.

15. The method of claim 1, wherein the polymer concentrate is mixed with the asphalt in a weight ratio of the polymer concentrate to the asphalt of 1:50 to 1:1.

16. A formulation comprising:

at least one polymer;

at least one compatibilizer precursor,

wherein the at least one compatibilizer precursor comprises at least one paraffinic oil, at least one petroleum extract, at least one naphthenic oil, at least one aromatic oil, at least one re-refined engine oil bottom (REOB), at least one engine oil residue (EOR), at least one re-refined heavy vacuum distillation bottom (RHVDB), at least one re-refined heavy vacuum distillation oil (RHVDO), at least one re-refined vacuum tower bottom (RVTB), at least one vacuum tower bottom (VTB), or any combination thereof; and

asphalt;

wherein the formulation is a polymer modified asphalt (PMA).

17. The formulation of claim 16, wherein the at least one polymer comprises at least one polyolefin, oxidized polyethylene (OPE), polyethylene-polypropylene elastomer, ground tire rubber (GTR), isotactic polypropylene (IPP), atactic polypropylene (APP), styrene-butadiene-styrene (SBS) copolymer, a styrene-ethylene-butylene-styrene (SEBS) copolymer, polyvinyl butyral (PVB) or any combination thereof.

18. A polymer modified asphalt (PMA) composition comprising:

a polymer concentrate comprising:

at least one compatibilizer precursor and at least one polymer,

wherein the at least one compatibilizer precursor comprises at least one paraffinic oil, at least one petroleum extract, at least one naphthenic oil, at least one aromatic oil, at least one re-refined

engine oil bottom (REOB), at least one engine oil residue (EOR), at least one re-refined heavy vacuum distillation bottom (RHVDB), at least one re-refined heavy vacuum distillation oil (RHVDO), at least one re-refined vacuum tower 5 bottom (RVTB), at least one vacuum tower bottom (VTB), or any combination thereof; and

asphalt.

19. The PMA composition of claim **18**, wherein the polymer concentrate is present in the composition in a 10 weight ratio of the polymer concentrate to the asphalt of 1:50 to 1:1.

20. The PMA composition of claim **18**, wherein the at least one polymer comprises at least one polyolefin, oxidized polyethylene (OPE), polyethylene-polypropylene 15 elastomer, ground tire rubber (GTR), isotactic polypropylene (IPP), atactic polypropylene (APP), styrene-butadiene-styrene (SBS) copolymer, a styrene-ethylene-butylene-styrene (SEBS) copolymer, polyvinyl butyral (PVB) or any combination thereof. 20

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